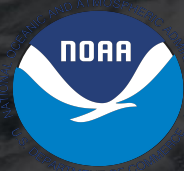


NOAA National Weather Service

Climate-Ready Forecasting: Transforming Weather Services in the U.S. Caribbean

Ernesto Rodríguez-Fernández
Meteorologist-In-Charge
NOAA National Weather Service



National Weather Service

Mission and Vision

Mission:

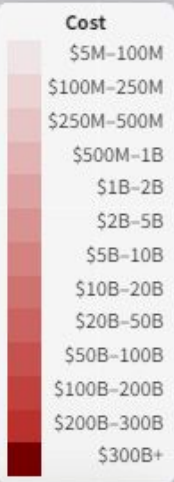
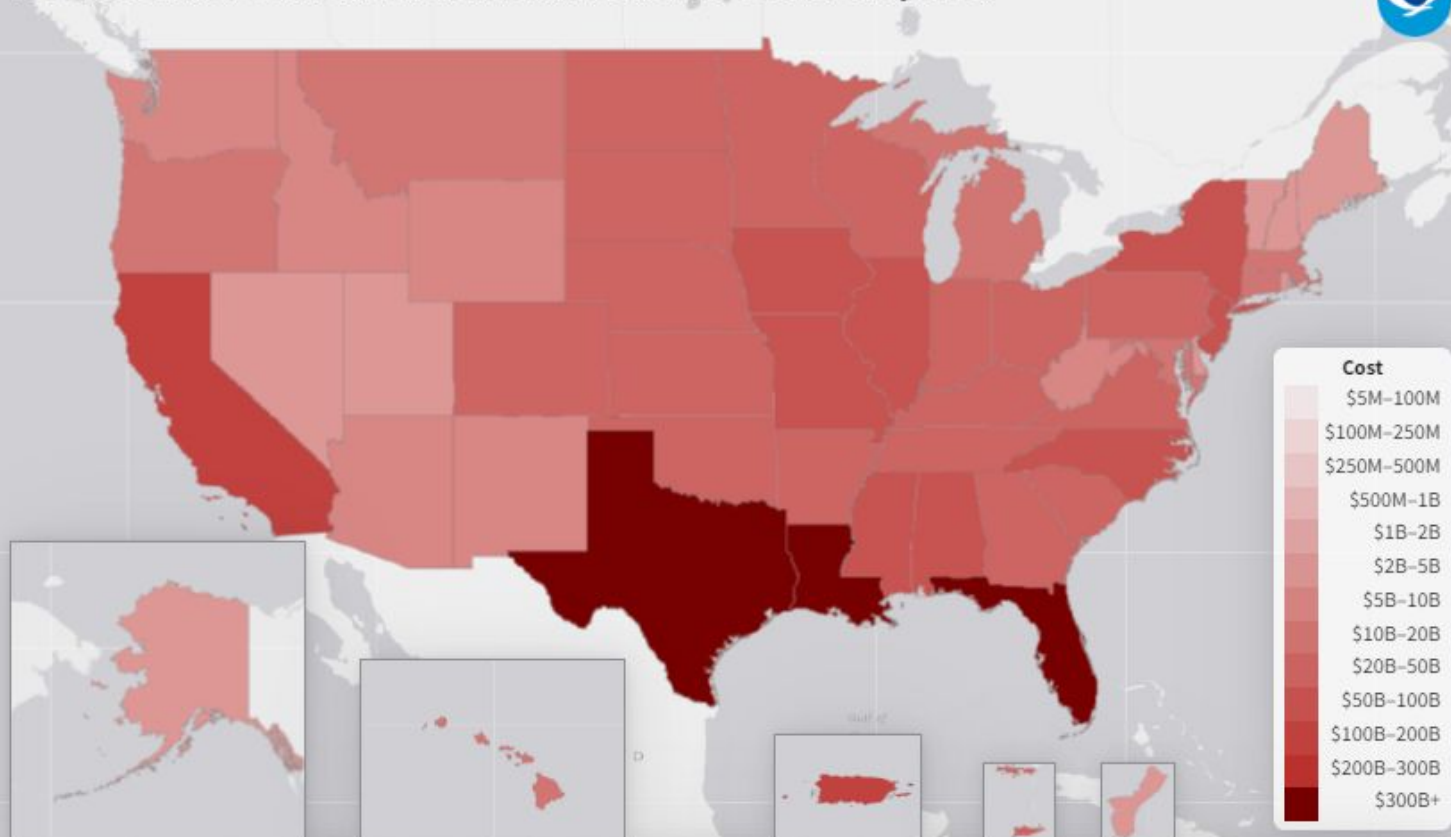
Provide weather, water, and **climate** data, forecasts, warnings and impact-based decision support services for the protection of life and property and enhancement of the national economy.

Vision:

A Weather-Ready Nation Society is prepared for and responds to weather, water, and **climate** dependent events.



1980-2023 Billion-Dollar Weather and Climate Disaster Cost (CPI-Adjusted)



United States

Drought:	\$350B+	Flooding:	\$100B-200B	Freeze:	\$20B-50B	Severe Storm:	\$450B+
Tropical Cyclone:	\$1.3T+	Wildfire:	\$100B-200B	Winter Storm:	\$50B-100B	All Disasters:	\$2.6T+



[US Caribbean \(globalchange.gov\)](https://globalchange.gov)



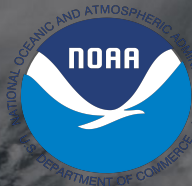
Fuente: Díaz, E., Terando, A., Gould, W., Bowden, J., Chardón, P., Meléndez, M., and Morell, J. (2021). Working Group 1: Geophysical and Chemical Scientific Knowledge. State of the Climate Report. Puerto Rico Climate Change Council. Díaz, E. and Terando, A. [Eds.]

[Resumen del informe del Estado del Clima PR Capítulo 1 \(pr-ccc.org\)](#)

Key Messages

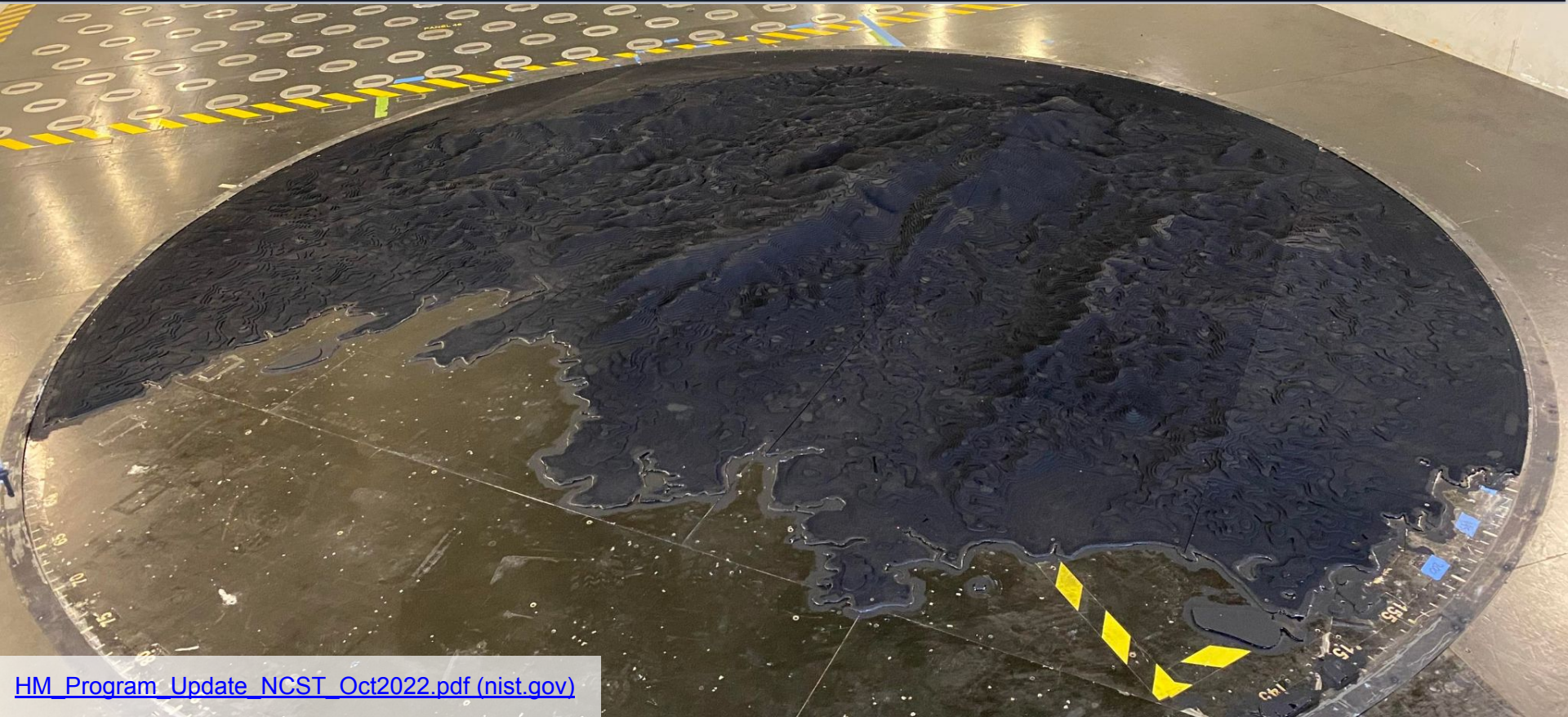
1. **Hurricanes** are a major threat to both Puerto Rico and the U.S. Virgin Islands. **Hurricane extreme winds, rainfall rates, storm surge heights** due to sea level rise, and the number of the strongest (Category 3, 4, and 5) hurricanes are all projected to increase in a warming climate.
2. Future changes in total precipitation are uncertain, but **extreme precipitation is projected to increase**, with associated increases in the intensity and frequency of flooding.
3. **Temperatures in Puerto Rico and the U.S. Virgin Islands have risen almost 2°F since 1950.** Under a higher emissions pathway, historically unprecedented warming is projected during this century, including increases in extreme heat events.

Extreme Winds







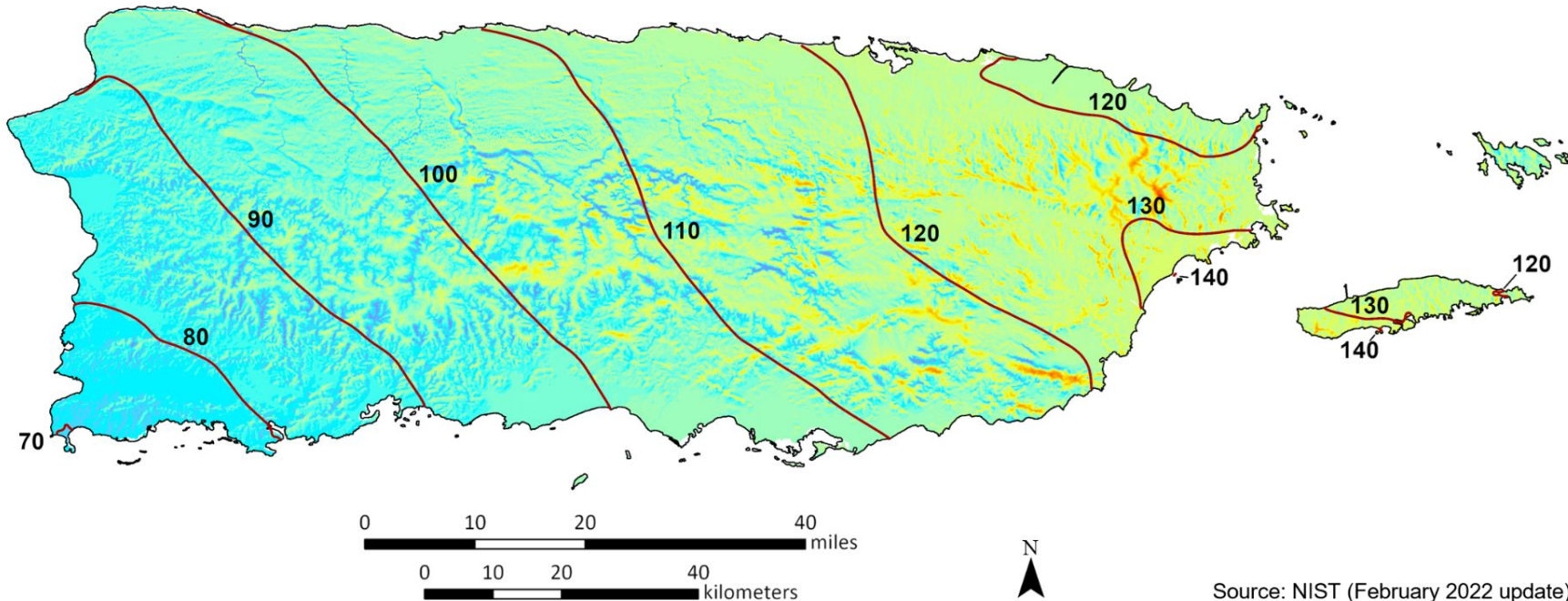


Peak gust wind speed with topographic effects (mph)

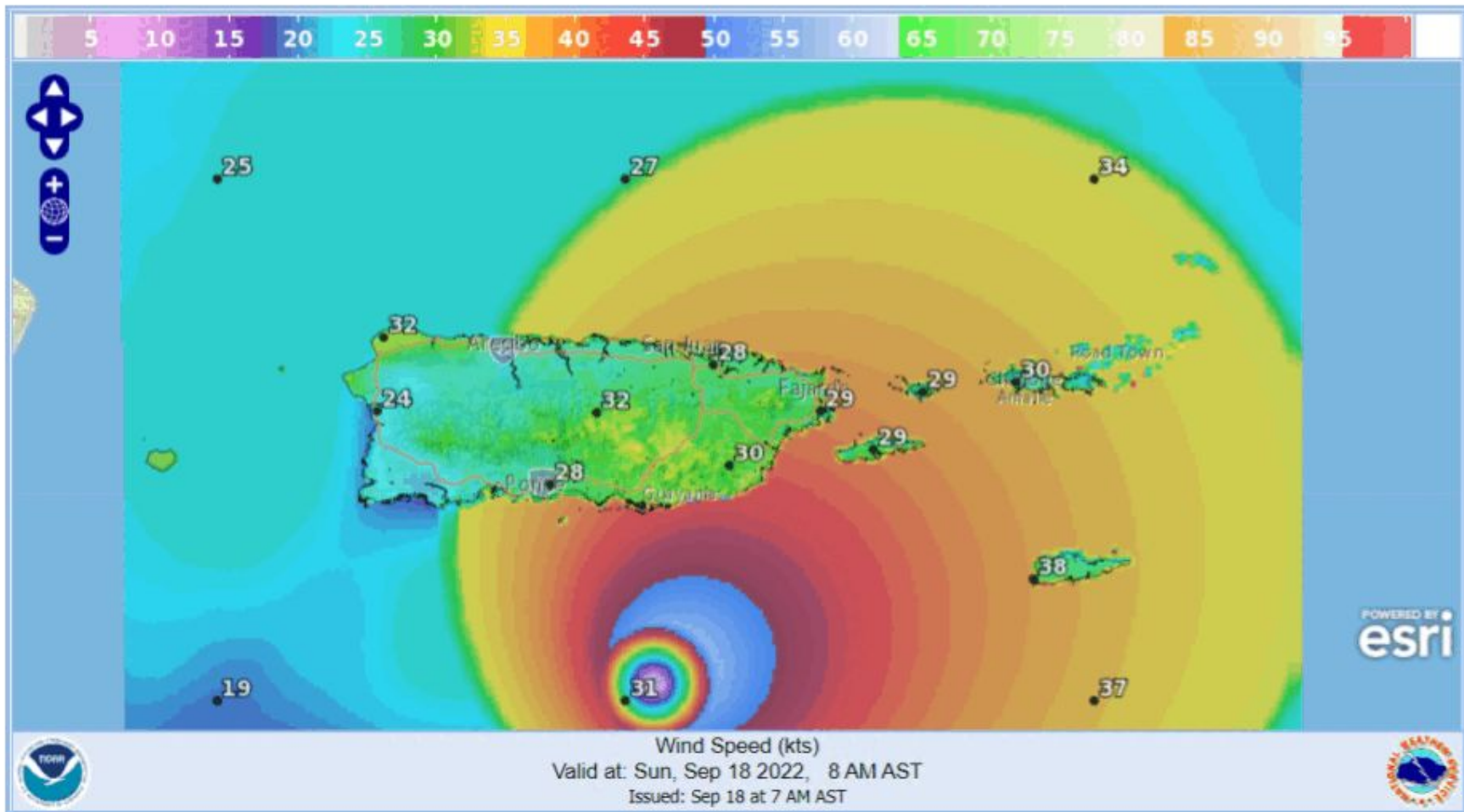
(1 mph = 0.447 m/s)

- < 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- 100 - 110
- 110 - 120
- 120 - 130
- 130 - 140
- 140 - 150
- 150 - 160
- 160 - 170
- 170 - 180
- 180 - 190
- 190 - 200
- 200 - 210
- 210 - 220
- 220 - 230

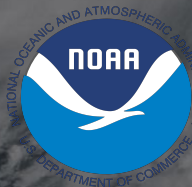
Peak gust wind speeds without topographic effects indicated by red contours (mph)



Source: NIST (February 2022 update)

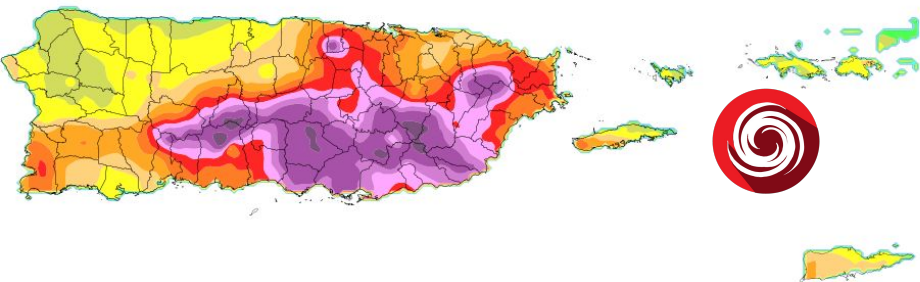


Flash Flooding

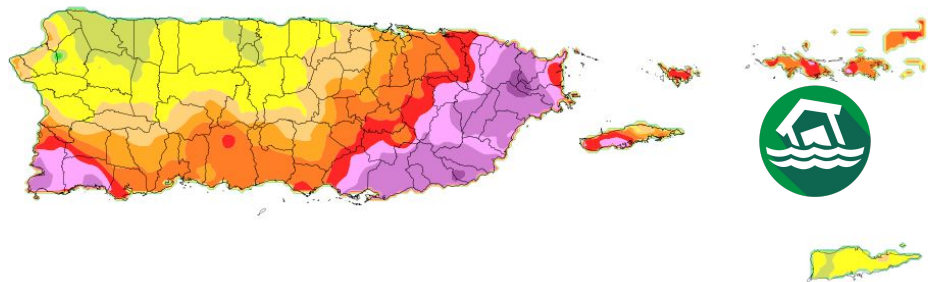


First, Hurricane Fiona dropped over 30" of rain on PR. Then, recovery and aid workers were hit with 15"-20" more.

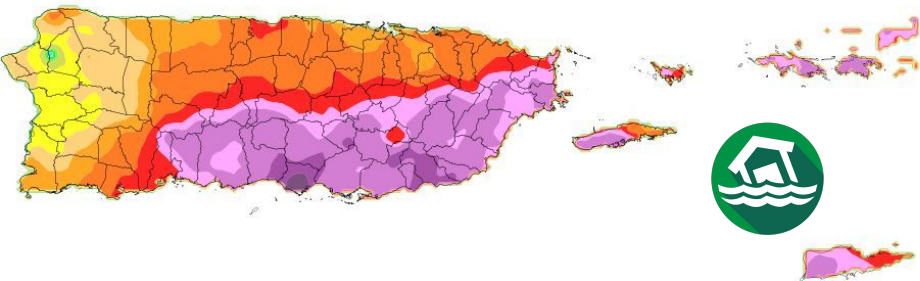
Valid from 09/16/2022 18Z to 09/20/2022 12Z



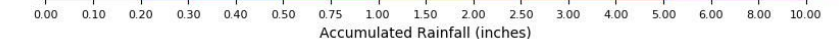
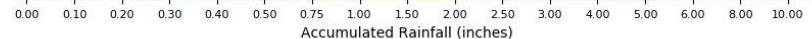
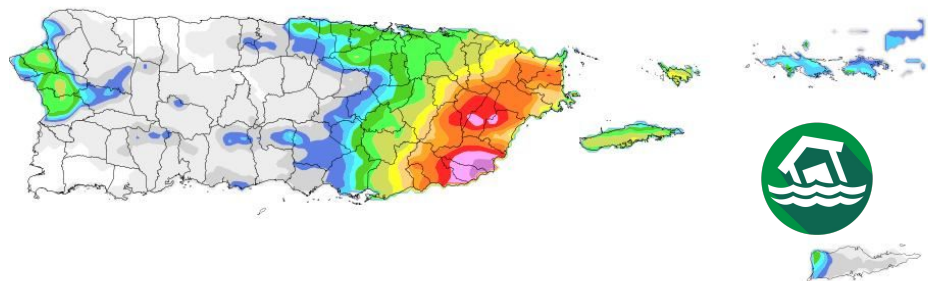
Valid from 10/26/2022 00Z to 10/28/2022 12Z



Valid from 11/04/2022 18Z to 11/08/2022 12Z

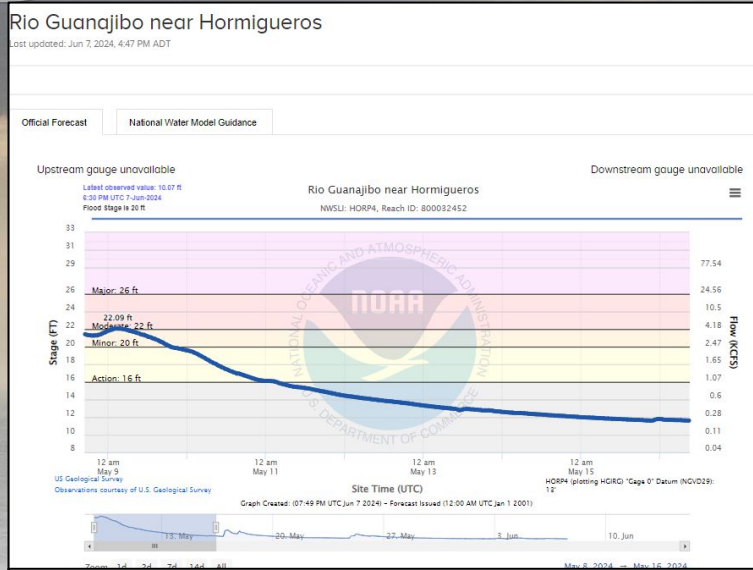


Valid from 11/15/2022 00Z to 11/16/2022 00Z





Solution to Communication Gap... Putting water on a map!



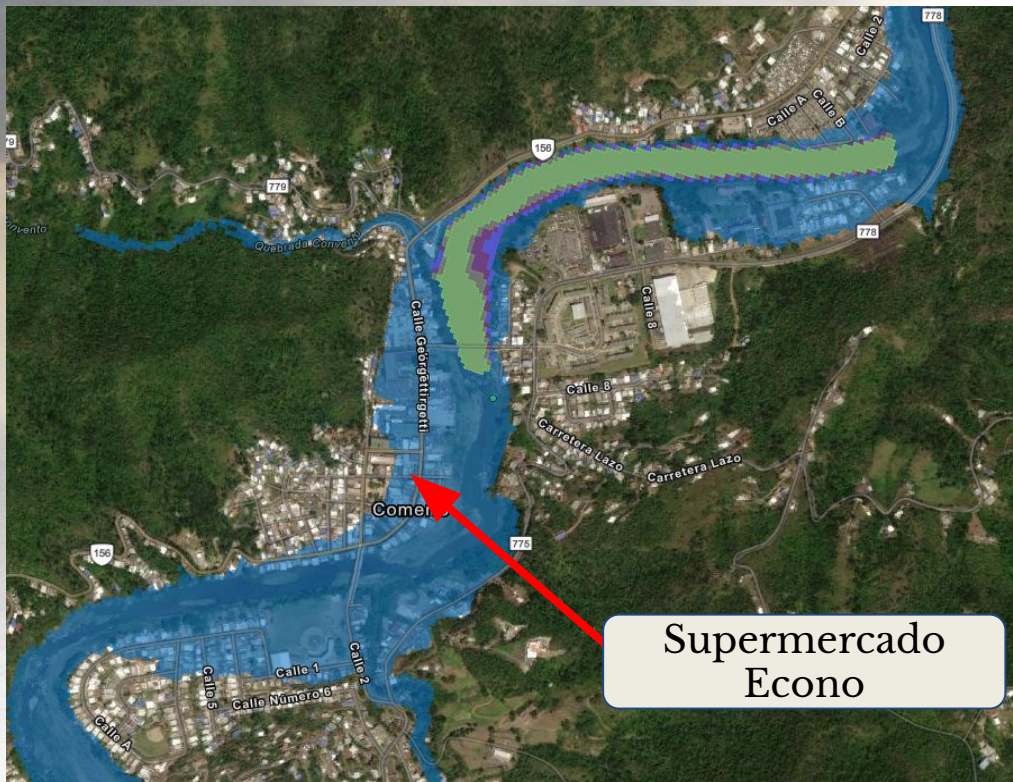
Flood Impacts[®]

- 21 - At 21 feet...the river begins to affect area homes ... residential flooding expected.
- 20.3 - Between 20 and 22 feet ... river is out of its banks and flooding CARR #114 and CARR #347.
- 19 - Between 19.0 and 19.5 feet...Flooding along CARR #114 and CARR #309 in Hormigueros and Mayaguez.



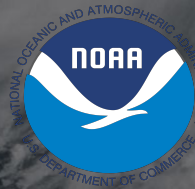
Flood Inundation Mapping (FIM) Services

Visualizing FIM: Hurricane Fiona in Comerio



Source: huracannnewspr4237 (Youtube)

Storm Surge



Puerto Rico/U.S. Virgin Islands Storm Surge & Waves

Project Team

Project Lead: Andre van der Westhuysen, NOAA NCEP

CO-PIs: Joannes Westerink, University of Notre Dame

Collaborators: Juan Gonzalez (CariCOOS/Wood Group PLC), Julio Morell (CariCOOS), Aurelio Mercado (UPRM), Reniel Calzada (UPRM/NOAA CSL), Volker Roeber (University of Hawaii), Dongming Yang (NOAA NCEP), Hugh Cobb (NOAA NCEP NHC), Carlos Anselmi (NOAA NWS San Juan Forecast Office), Ernesto Rodriguez (NOAA NWS San Juan Forecast Office), Luis Aponte (UPRM)

Federal Partners: Jamie Rhome (NOAA NVEP NHC), Jane Smith (USACE ERDC)

Project Overview and Results

The goal of this COMT project is to extend the present wave/surge operational forecasting capability from mild-sloped coastal areas such as the US East and Gulf of Mexico coasts to steep-sloped areas such as around Caribbean and Pacific islands and transition this capability to NOAA's National Hurricane Center and local WFOs. Broad project objectives are to: (1) compile a data set of observations collected around Puerto Rico and the USVI by the IOOS Caribbean Regional Association; (2) evaluate multiple, coupled wave/surge/inundation models against this data; (3) recommend the most suitable model for transition to operations and (4) assist with the transition. These outcomes will also be applicable to U.S. island regions in the Pacific and may therefore guide future implementations at NOAA's Central Pacific Hurricane Center.

U.S. island regions in the Caribbean and Pacific pose many challenges to the accurate modeling and prediction of hazardous wave-dominated storm surge inundation events. The relative importance of physical processes leading to inundation in steep-sloped, reef-edged island environments differs from those in milder-sloped mainland environments. Relatively little research has been done in these environments, constituting a significant knowledge gap. To compound this uncertainty, little observational data are available in many island environments. As a result, the U.S. National Weather Service (NWS) currently lacks operational surge and inundation guidance for these regions. An exception to this general data scarcity is Puerto Rico and the U.S. Virgin Islands (USVI), which frequently experience strong tropical and extra-tropical storms resulting in high waves, storm surge, and river flooding. A large number of observational instruments have been deployed here, many by IOOS Caribbean Regional Association partners, creating a valuable resource for the evaluation and advancement of operational wave/surge/inundation models of these areas.

NOAA upgrades storm surge forecasting model



NOAA has upgraded its Probabilistic Storm Surge (P-Surge) model – the primary model for predicting storm surge associated with high-impact weather like hurricanes and tropical storms – to version 3.0. This upgrade advances storm surge modelling and forecasting for the contiguous U.S. (CONUS), Puerto Rico and the U.S. Virgin Islands, and comes just in time for the 2023 hurricane season beginning on June 1 and running through November 30.

The upgrade includes a number of new capabilities that will help forecasters better understand the risk of storm surge, such as:

- New forecasts for surge, tide and waves for Puerto Rico and the U.S. Virgin Islands.
- The ability to run the model simultaneously for two storms. This capability can help during two landfalling storms impacting the CONUS, or one storm impacting the CONUS and one impacting Puerto Rico and/or the U.S. Virgin Islands.

National Hurricane Center Storm Surge Risk Maps

Category 1

Category 2

Category 3

Category 4

Category 5



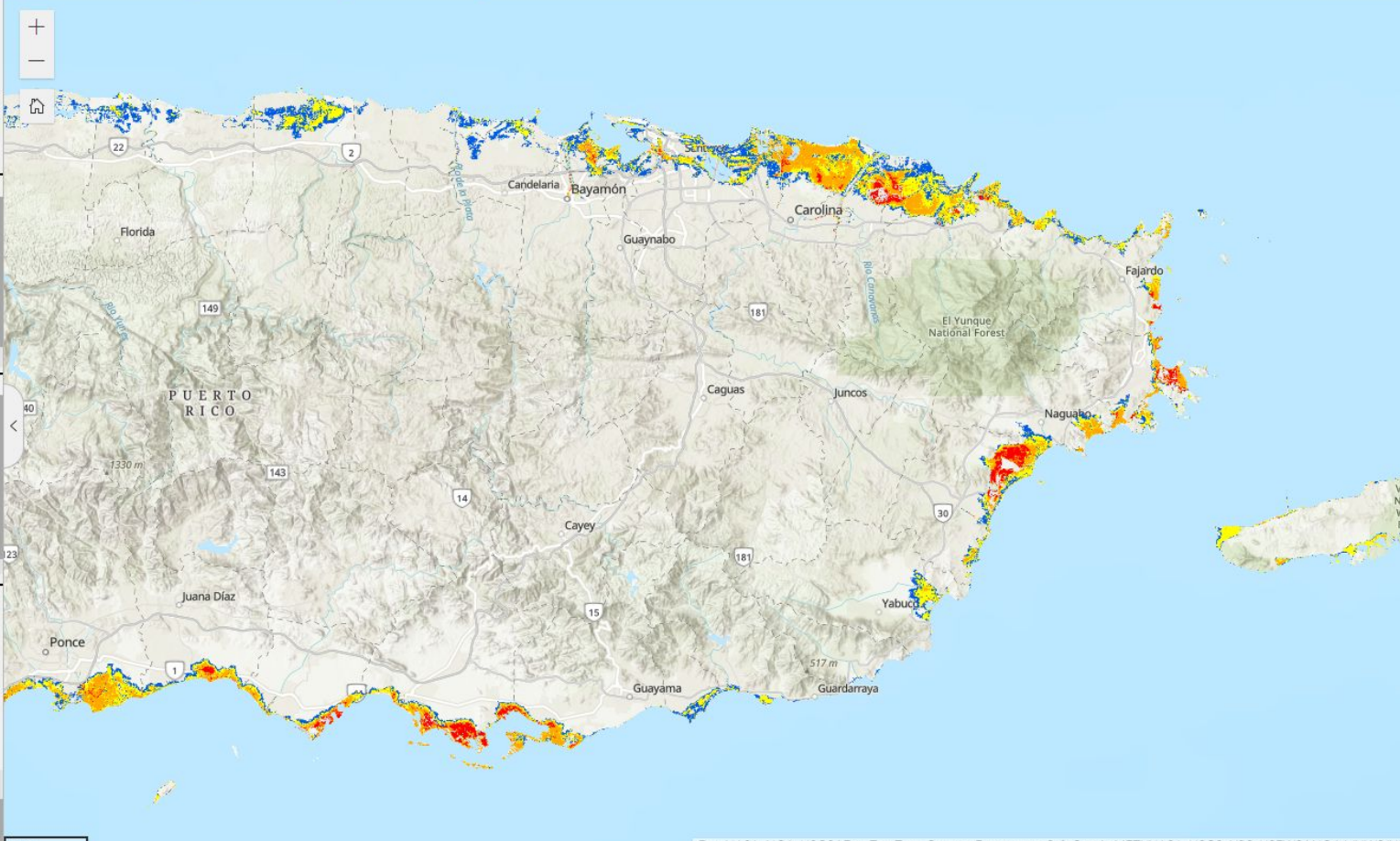
This is not a real-time product. For active tropical cyclones, please see hurricanes.gov and consult local products issued by the National Weather Service

Additional depiction of storm surge flooding vulnerability for people living in hurricane-prone coastal areas. These maps make it clear that storm surge is not just a beachfront phenomenon, with the risk of storm surge extending many miles inland from the immediate coastline in some areas. Storm Surge Risk Maps are provided for the US Gulf and East Coasts, Hawaii, Southern California, US territories - Puerto Rico, US Virgin Islands, Guam and American Samoa. Additional mapped areas include Alaska and parts of the Western Peninsula.

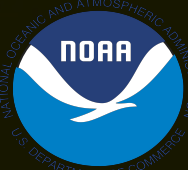
- US East and Gulf Coast
- Puerto Rico and USVI
- Hispaniola
- Hawaii (category 1-4)
- Southern California (category 1-2)
- Guam
- American Samoa

- Less than 3 feet above ground
- Greater than 3 feet above ground
- Greater than 6 feet above ground
- Greater than 9 feet above ground
- Leveed area
- Consult local officials for flood risk

Map Opacity
Storm Surge Risk Maps Category5 v3
Inundation Height

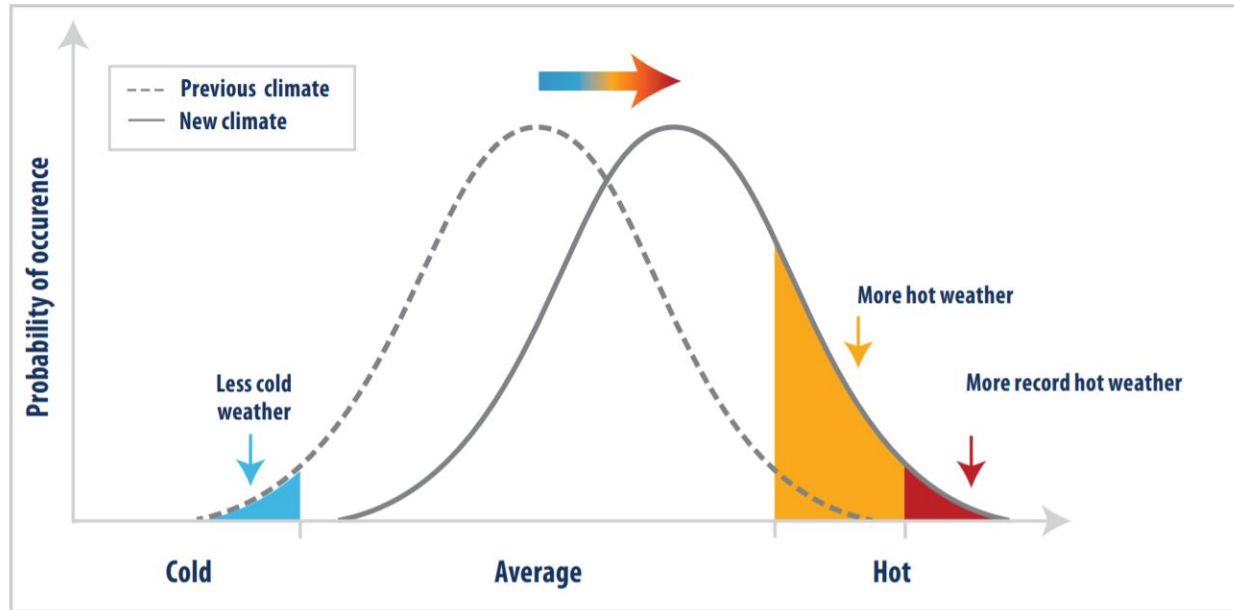


Excessive Heat



Climate change? How we can adapt?

Increase in Average Temperature



When average temperatures increase, the average temperature of “hot weather” and “record hot weather” will become even hotter. Source: IPCC, 2001? <https://www.cdc.gov/climateandhealth/pubs/extreme-heat-guidebook.pdf>

Extreme Heat Events in San Juan Puerto Rico: Trends and Variability of Unusual Hot Weather and its Possible Effects on Ecology and Society

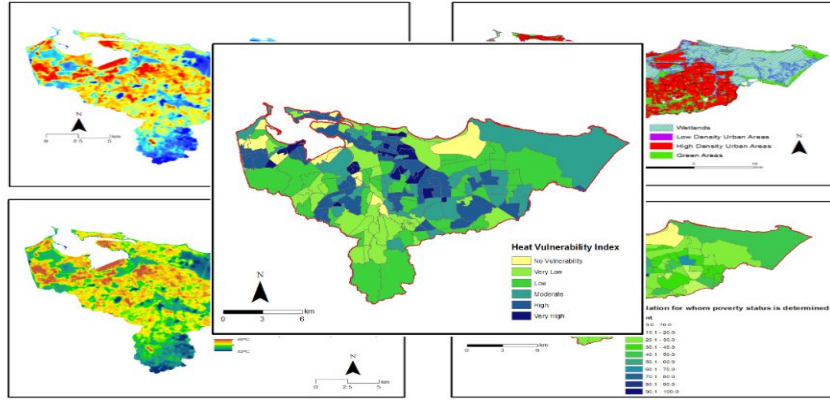
Pablo Méndez-Lázaro^{1*}, Odalys Martínez-Sánchez², Rafael Méndez-Tejeda³, Ernesto Rodríguez², Ernesto Morales² and Natalie Schmitt-Cortijo¹

¹University of Puerto Rico-Medical Sciences Campus, Graduate School of Public Health, Department of Environmental Health PO BOX 365067 San Juan PR 00936-5067, Puerto Rico

²National Weather Service, San Juan, PR Weather Forecast Office, 4000 Carretera 190 Carolina, PR 00979, Puerto Rico

³University of Puerto Rico-Carolina Campus, Laboratory of Atmospheric Sciences, PO Box 4800 Carolina P.R. 00984-4800, Puerto Rico

Pablo A. Méndez-Lázaro, Ph.D; Frank E Muller-Karger , Ph.D; Daniel Otis , Ph.D; Matthew J McCarthy, MS; Ernesto Rodriguez , MS
A Heat Vulnerability Index to Improve Urban Public Health in San Juan, Puerto Rico. Elsevier Editorial System for Applied Geography. Submitted January 15, 2016.



[Int J Biometeorol.](#) 2018 May;62(5):699-707. doi: 10.1007/s00484-016-1291-z. Epub 2016 Dec 15.

Climate change, heat, and mortality in the tropical urban area of San Juan, Puerto Rico

Pablo A Méndez-Lázaro¹, Cynthia M Pérez-Cardona², Ernesto Rodríguez³, Odalys Martínez³, Mariela Taboas⁴, Arelis Bocanegra⁴, Rafael Méndez-Tejeda⁵

Affiliations + expand

PMID: 27981339 DOI: 10.1007/s00484-016-1291-z

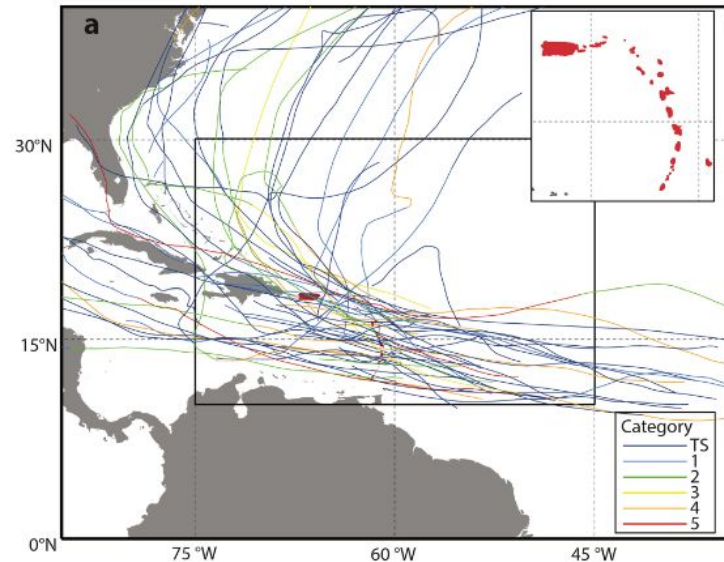
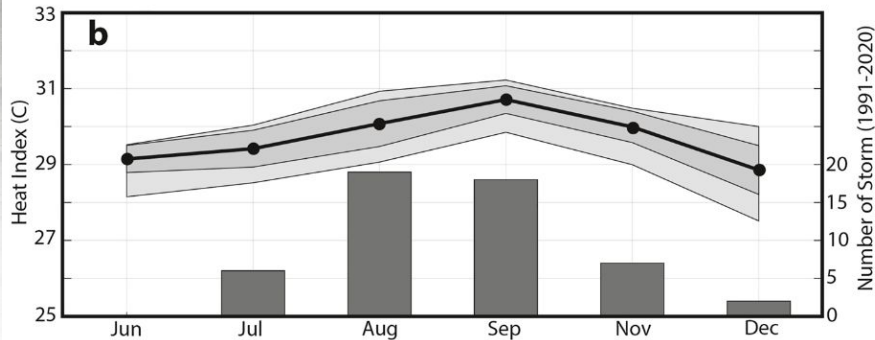
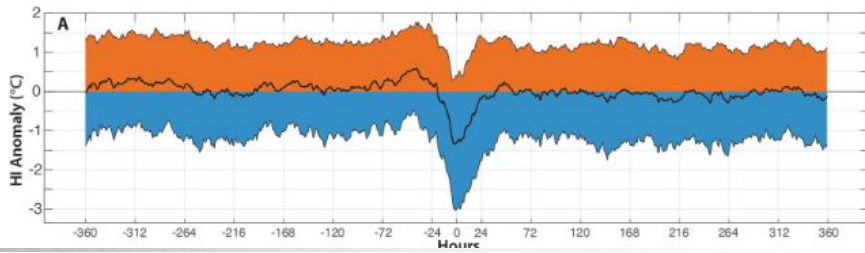
Abstract

Extreme heat episodes are becoming more common worldwide, including in tropical areas of Australia, India, and Puerto Rico. Higher frequency, duration, and intensity of extreme heat episodes are triggering public health issues in most mid-latitude and continental cities. With urbanization, land use and land cover have affected local climate directly and indirectly encouraging the Urban Heat Island effect with potential impacts on heat-related morbidity and mortality among urban populations. However, this association is not completely understood in tropical islands such as Puerto Rico. The present study examines the effects of heat in two municipalities (San Juan and Bayamón)

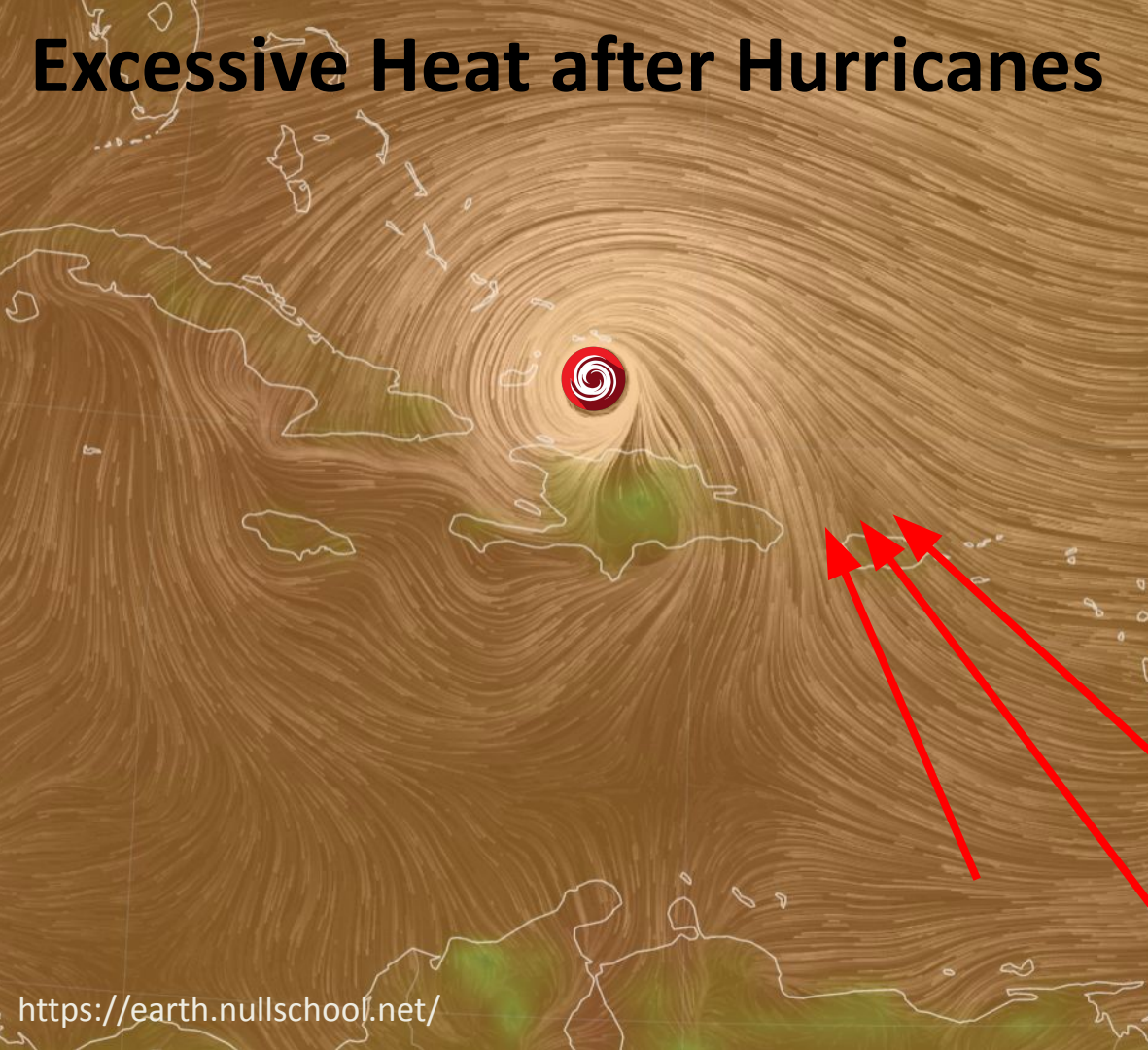
Hurricanes and Anomalous Heat in the Caribbean

Zack Guido^{1,2} , Teddy Allen³ , Simon Mason⁴ , and Pablo Méndez-Lázaro⁵ 

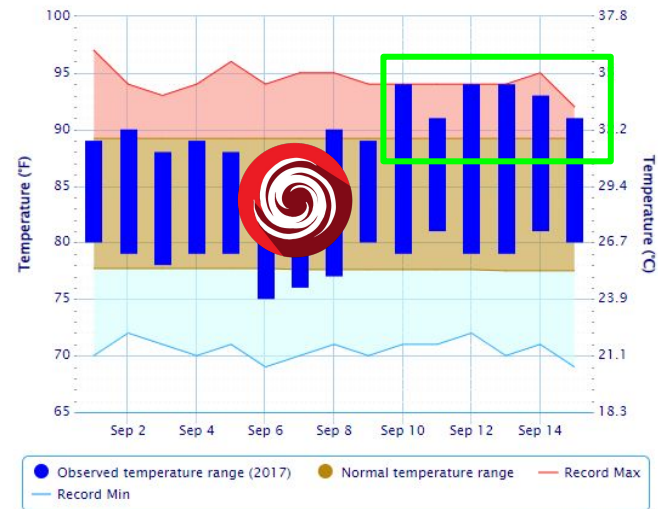
¹Arizona Institutes for Resilient Environments and Societies, University of Arizona, Tucson, AZ, USA, ²School of Natural Resources and Environment, University of Arizona, Tucson, AZ, USA, ³Caribbean Institute for Meteorology and Hydrology, St. James, Barbados, ⁴International Research Institute for Climate and Society, Earth Institute, Columbia University, Palisades, NY, USA, ⁵Environmental Health Department, Graduate School of Public Health, University of Puerto Rico-Medical Campus, San Juan, Puerto Rico



Excessive Heat after Hurricanes



Daily Temperature Data – San Juan Area, PR (ThreadEx)



Powered by ACIS

How Blackouts during Heat Waves Amplify Mortality and Morbidity Risk

Brian Stone, Jr.,* Carina J. Gronlund, Evan Mallen, David Hondula, Marie S. O'Neill, Mayuri Rajput, Santiago Grijalva, Kevin Lanza, Sharon Harlan, Larissa Larsen, Godfried Augenbroe, E. Scott Krayenhoff, Ashley Broadbent, and Matei Georgescu

[Cite This: Environ. Sci. Technol. 2023, 57, 8245–8255](#)

[Read Online](#)

ACCESS |

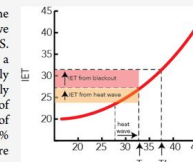
[Metrics & More](#)

[Article Recommendations](#)

[Supporting Information](#)

ABSTRACT: The recent concurrence of electrical grid failure events in time with extreme temperatures is compounding the population health risks of extreme weather episodes. Here, we combine simulated heat exposure data during historical heat wave events in three large U.S. cities to assess the degree to which heat-related mortality and morbidity change in response to a concurrent electrical grid failure event. We develop a novel approach to estimating individually experienced temperature to approximate how personal-level heat exposure changes on an hourly basis, accounting for both outdoor and building-interior exposures. We find the concurrence of a multiday blackout event with heat wave conditions to more than double the estimated rate of heat-related mortality across all three cities, and to require medical attention for between 3% (Atlanta) and more than 50% (Phoenix) of the total urban population in present and future time periods. Our results highlight the need for enhanced electrical grid resilience and support a more spatially expansive use of tree canopy and high albedo roofing materials to lessen heat exposures during compound climate and infrastructure failure events.

KEYWORDS: extreme heat event, infrastructure failure, heat-related mortality, climate change, urban heat management, compound climat, infrastructure failure events

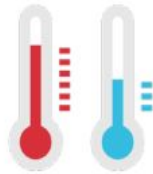


Comparing WBGT and Heat Index

	WBGT	HEAT INDEX
Measured in the sun	●	●
Measured in the shade	●	●
Uses temperature	●	●
Uses relative humidity	●	●
Uses wind	●	●
Uses cloud cover	●	●
Uses sun angle	●	●



solar radiation



temperature



relative humidity

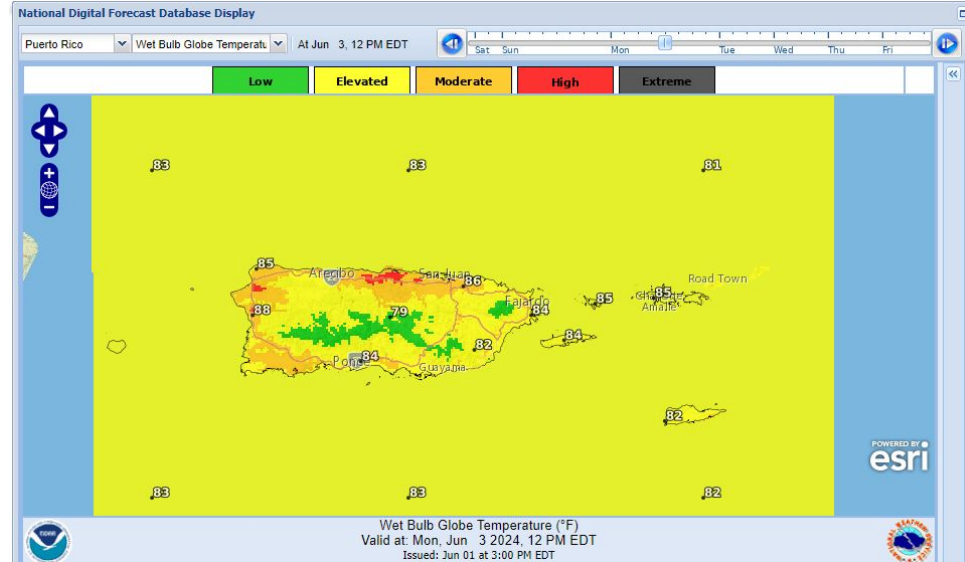


wind speed

Who is WBGT Most Helpful for?

This parameter is best suited for active people such as outdoor workers, athletes, marching band, and others performing strenuous outdoor activities.

WBGT can be used to establish guidelines for activity modifications during exercise or outdoor work.



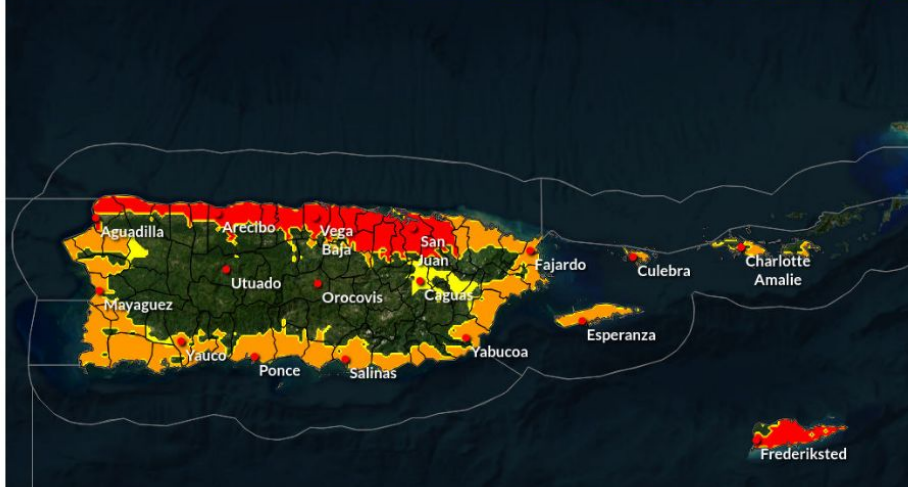
Perspectiva del Tiempo Peligroso

Excessive Heat Risk for Mon/Mon Night

Valid 8 AM Mon May 27, 2024 to 8 AM Tue May 28, 2024

Weather Forecast Office
San Juan, PR

Issued May 23, 2024 10:26 AM AST



24 Hr Hazard Risks

Filter Elements ▾

	Today	Fri	Sat	Sun	Mon	Tue	Wed
Lightning	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	White
Excessive Rainfall	Orange	Orange	Orange	Orange	Orange	Orange	Orange
Excessive Heat	Yellow	Yellow	Orange	Orange	Red	Yellow	Orange
Wind	Yellow	White	White	White	White	Yellow	White
Marine Hazard	White	White	White	White	White	White	White
Rip Current	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow



Risk Level	Category	Definition
White	None	Little to no risk from expected heat.***Poco o ningún riesgo por el calor esperado.***
Yellow	Limited	This level of heat affects primarily those individuals extremely sensitive to heat, especially when outdoors without effective cooling and/or adequate hydration.***Este nivel de calor afecta principalmente a aquellas personas extremadamente sensibles al calor, especialmente cuando están al aire libre sin enfriamiento efectivo y/o hidratación adecuada***
Orange	Elevated	This level of heat affects most individuals sensitive to heat, especially those without effective cooling and/or adequate hydration. Impacts possible in some health systems and in heat-sensitive industries.***Este nivel de calor afecta a la mayoría de las personas sensibles al calor, especialmente aquellas sin enfriamiento efectivo y/o hidratación adecuada. Posibles impactos en algunos sistemas de salud y en industrias sensibles al calor.***
Red	Significant	This level of heat affects anyone without effective cooling and/or adequate hydration. Impacts likely in some health systems, heat-sensitive industries and infrastructure.***Este nivel de calor afecta a cualquier persona sin un enfriamiento efectivo y/o una hidratación adecuada. Es probable que se produzcan impactos en algunos sistemas de salud, industrias e infraestructuras sensibles al calor.***
Purple	Extreme	This level of rare and/or long-duration extreme heat with little to no overnight relief affects anyone without effective cooling and/or adequate hydration. Impacts likely in most health systems, heat-sensitive industries and infrastructure.***Este nivel de calor extremo poco común y/o de larga duración con poco o ningún alivio durante la noche afecta a cualquier persona sin un enfriamiento efectivo y/o una hidratación adecuada. Es probable que se produzcan impactos en la mayoría de los sistemas de salud, industrias e infraestructuras sensibles al calor.***

NWS HeatRisk



NWS Director **Ken Graham** speaking at the press conference announcing HeatRisk.



HeatRisk subject matter experts from left to right: Public Program Coordinator **Jessica Lee**, Public Program Manager **Kim McMahon**, WRH STID Chief **Mike Staudenmaier**, and CDC Senior Health Scientist **Rish Vaidyanathan, Ph.D.**

Overview

NWS HeatRisk is a color-numeric-based index that uses high-resolution weather, climate, and Centers for Disease Control and Prevention (CDC) heat-health data to identify potentially dangerous heat.

It provides a daily value of expected heat risk for each 24-hour period within any upcoming 7-day forecast period.

HeatRisk Considerations

HeatRisk takes into consideration:

- How unusual the heat is for the time of year
- Duration of the heat, including both daytime and nighttime temperatures
- If those temperatures pose an elevated risk of heat-related impacts based on CDC data

HeatRisk supplements the official NWS heat watch, warning, and advisory products.

Understanding HeatRisk

HeatRisk is divided into 5 categories and identifies the following:

- The groups potentially most at risk
- How common the heat is
- For those at risk, what actions can be taken

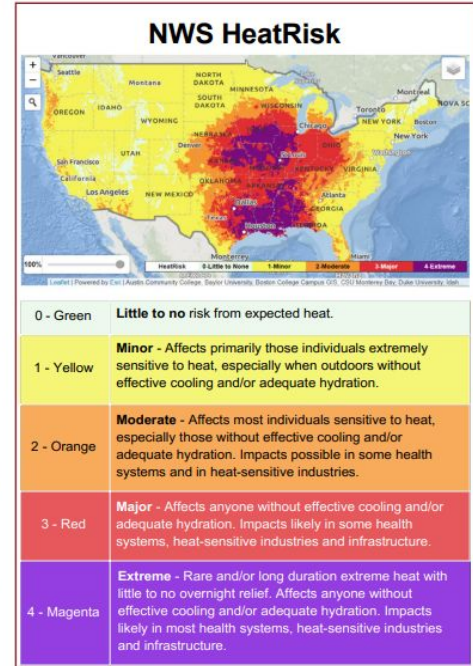
Each HeatRisk level is also accompanied by recommendations for heat protection. It is especially useful for decision makers and heat-sensitive populations who may need to take actions below current NWS heat product levels.

** HeatRisk is an experimental product which means that there is no guarantee of timely availability. Changes may occur without advance notice.*

How to Access

- Interactive CONUS Viewer: <https://www.wpc.ncep.noaa.gov/heatrisk>
- NDFD webpage: <https://digital.weather.gov/>

Please provide feedback via the SurveyMonkey link [here](#). Feedback can also be provided via your local or regional NWS office.





Impact Decision Support Services (IDSS)

- TJUA Radar
- Excessive Heat Risk
- Excessive Heat Hazards
- Tropical Weather Outlook**
- Perspectiva del Tropico
- Rip Current Risk

Monitoring the Tropics

8 AM AST Thursday, July 20th, 2023



San Juan, PR

WEATHER FORECAST OFFICE



THIS IS NOT A TRACK FORECAST

The areas enclosed on the graph represent the potential formation area during the forecast period.



The National Hurricane Center is monitoring two systems across the Atlantic Basin:

Active Storm ▲: The National Hurricane Center is issuing advisories on Tropical Storm Don, located over the central Atlantic.

1. **Tropical Wave** ▲: While dry air to the north may prevent significant organization during the next couple of days, environmental conditions could become more conducive for some development this weekend as the system moves westward across the central tropical Atlantic.

✓ Uncertainty is too high, but residents and visitors should continue to monitor forecast updates for potential hazard risks from the National Hurricane Center & National Weather Service, San Juan office.

Formation Chance	1 Tropical Wave
48 hours	Low, 0%
7 days	Low, 20%

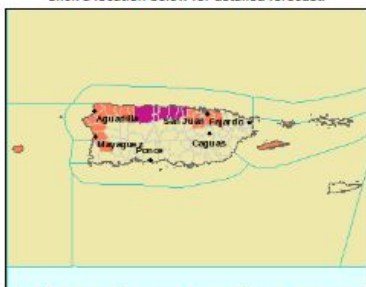
[f](#) [t](#) @NWSsanJuan #PRwx #USVIwx

For more information, visit: hurricane.gov | weather.gov/sju

The National Hurricane Center is monitoring a tropical wave with a low formation chance in the next seven days.

[Hide Caption](#)

Click a location below for detailed forecast.



Watches, Warnings & Advisories



- Excessive Heat Warning
- Heat Advisory
- Hazardous Weather Outlook



<https://www.weather.gov/sju/>

Last Map Update: Thu, Jul. 20, 2023 at 3:47:26 pm A.S.T



FEMA

> Alertas del Servicio Nacional de Meteorolo...

+ Prepárese

+ Recursos de desastre

> English Content

> Como ayudar

Blog de FEMA

Hace 5 días

Guía para principiantes sobre los perros de apoyo emocional

> Después de acontecimientos estresantes y traumáticos las personas afectadas pueden buscar alivio en muchas formas, como hablar con amistades y seres queridos, buscando asesoramiento profesional o...

> Acerca de/Contáctenos

> Llame al 911 en caso de emergencia, o lla...



WIRELESS
**EMERGENCY
ALERTS**
CAPABLE



Emergency alert:
Severe

Flash Flood Warning this area til 6:15 PM AST. Avoid flood areas. Check local media. - NWS

OK

